CHEMICAL HAZARD SUMMARY

Canadian Centre for Occupational Health and Safety
250 Main Street East
Hamilton Ontario Canada L8N 1H6

No. 44
ISSN 0827-8830

VINYL CHLORIDE

(CAS 75-01-4 ; CH_2=CHCl)

SCOPE OF THE DOCUMENT

This document focuses on the hazards of vinyl chloride. The toxicity, fire and explosion hazards, and reactivity of vinyl chloride are described. Information relevant to the workplace is emphasized. Special attention is given to the main hazard presented by vinyl chloride.

CCOHS CCHST

VINYL CHLORIDE - CHEMICAL HAZARD SUMMARY NO. 44

Each publication produced by CCOHS undergoes several stages of review. As part of this review, representatives from government, employers, and labour are requested to comment on draft copies of CCOHS documents for technical accuracy and usability.

Although every effort is made to ensure accuracy and completeness of the information, it is understood that CCOHS makes no warranty as to the accuracy or completeness of such information and assumes no liability for any damages or loss suffered as a result of any inaccuracy or incompleteness therein.

This publication is available in both official languages.

Cette publication est disponible dans les deux langues officielles.

CCOHS NUMBER C88-8E
ISBN 0-660-13101-3
DSS CATALOGUE NUMBER CC273-4/88-8E

Published 1988

---

250 Main Street East
Hamilton Ontario
L8N 1H6
416-572-2981
FAX 416-572-2206
Telex 061-8532

CCOHS/CCHST

TABLE OF CONTENTS

I.	MAIN HAZARDS	1
II.	OCCUPATIONAL EXPOSURE	1
III.	HEALTH HAZARDS	2
	Removal from the Body	2
	Effects of Short-Term Exposure in Humans	2
	Effects of Long-Term Exposure in Humans	3
	Toxicity Data in Animal and Laboratory Tests	5
IV.	FIRE AND EXPLOSION HAZARDS	6
V.	CHEMICAL REACTIVITY	7
VI.	EXPOSURE LIMITS	7
VII.	EXPOSURE CONTROLS	7
	Protective Clothing	7
	Respiratory Protection	8
VIII.	STORAGE AND HANDLING	8
IX.	FIRST AID	9
	Inhalation	9
	Skin	9
	Eyes	9
	General	9
X.	FIREFIGHTING	9
XI.	CLEAN-UP AND DISPOSAL	10
XII.	REFERENCES	11

CCOHS/CCHST

I. MAIN HAZARDS

Vinyl chloride can cause cancer in humans. It produces a rare type of cancer of the liver known as angiosarcoma. Cancers at other sites are also associated with exposure to vinyl chloride. Vinyl chloride can cause genetic changes in humans. Current very low workplace limits have eliminated both the cancer hazard and genetic hazards.

Vinyl chloride is highly reactive and extremely flammable. It poses a dangerous fire and explosion hazard.

II. OCCUPATIONAL EXPOSURE

Vinyl chloride is the starting material in the manufacture of polyvinyl chloride (PVC) plastics. These plastics are used in building and construction industries (in pipes, ducts, floor tiles, electrical wire and cable), packaging (in films, sheets, bags and bottles), clothing, insulation, transportation materials (in automobile tops, upholstery and mats), recreational products (in records and toys) and a variety of consumer goods. A small amount (less than 5 percent) of vinyl chloride is used in the production of 1,1,1-trichloroethane (methyl chloroform).

Workers are exposed to vinyl chloride during its manufacture, in the production of PVC resins, and in the processing and fabrication of the unfinished resin into a variety of end products. The loading and unloading of tank cars and trucks also represents an exposure risk.

In the old PVC polymerization plants, polymerization reactor vessels were cleaned entirely by hand. Cleaners were lowered into the vessel and spent several hours daily scraping off the PVC crust which remained on the reactor wall. During this operation, they were exposed to concentrations of vinyl chloride reaching several thousand parts per million (ppm). This practice was phased out in the late 1960s and early 1970s. The cleaning is now mostly automated and workers, wearing appropriate respiratory and protective equipment, need only enter the reactor for short periods of time (10-15 minutes) every 20-30 polymerization processes.

Workers handling finished PVC products may be exposed to trace amounts of unchanged vinyl chloride remaining from the polymerization process. These tiny amounts are unlikely to present a health hazard.

Vinyl chloride is a colourless gas at room temperature and pressure, but is usually handled as a liquid under pressure. The colourless liquid readily evaporates to form a vapour and, at high concentrations, has a sweetish odour. The odour is not detectable below 2000 ppm and therefore does not give adequate warning to prevent too much exposure by inhalation. Nowadays, sensitive warning devices are available and can detect vinyl chloride well below 1 ppm. Most exposure to vinyl chloride is through inhalation and, less frequently, through skin absorption. Ingestion of the liquid is highly unlikely.

General information on routes of exposure is available in the CCOHS publication "How Workplace Chemicals Enter the Body."[1]

III. HEALTH HAZARDS

Removal from the Body

Most vinyl chloride taken into the body is rapidly broken down in the liver. The breakdown products are mainly excreted in the urine. The breakdown products are responsible for many of the toxic effects of vinyl chloride. Small amounts of unchanged vinyl chloride and carbon dioxide are eliminated in exhaled air.

Effects of Short-Term Exposure in Humans

Vinyl chloride has a relatively low toxicity following short-term exposures. This may explain, in part, why the health hazards of vinyl chloride were not initially recognized. There was much greater concern over the fire and explosion hazards.

Inhalation

Short-term exposure to high concentrations of vinyl chloride can produce dizziness, light-headedness, euphoria, nervousness, drowsiness, headache, blurred vision, impaired hearing and confusion. Many of these symptoms resemble those of alcohol intoxication. The first signs usually appear following exposures to concentrations of 8000 to 10,000 ppm.

Vinyl chloride can cause moderate irritation to the nose and throat, and people find high concentrations unpleasant. Very high concentrations can lead to unconsciousness and death. Two cases of accidental death due to exposure to high concentrations (concentrations in excess of 100,000 ppm) were reported in Ontario in 1958 and 1959.[2] Both deaths were the result of respiratory failure.

Eyes

Liquid vinyl chloride can cause frostbite which may cause permanent damage to the eyes. Vapours are moderately irritating to the eyes.

Skin

Liquid vinyl chloride can cause frostbite. If a polymerization inhibitor (phenol) is included, it may cause burns.

Ingestion

Ingestion (swallowing) of liquid vinyl chloride is unlikely in the workplace and has not been reported.

Effects of Long-Term Exposure in Humans

Most of the health problems caused by vinyl chloride develop following high-level, long-term exposure. Such exposures existed in old plants where reactor cleaners were repeatedly exposed to concentrations of vinyl chloride reaching several thousand ppm. Almost all cases of angiosarcoma of the liver and chronic diseases, such as vinyl chloride disease (acroosteolysis) and liver damage, occurred in these reactor cleaners. Brief descriptions of the major disorders associated with vinyl chloride follow.

Cancer

Today, the main health concern with vinyl chloride is its potential to cause cancer. Angiosarcoma of the liver (a rare type of liver cancer) is the only cancer in humans that has been definitely associated with exposure to vinyl chloride.[3] The association between vinyl chloride and angiosarcoma was first reported in 1974.[4] Since then close to 130 cases have been reported worldwide.* Ten of these cases were in Quebec, all among workers in one plant.[5] Almost all cases of angiosarcoma have occurred in reactor cleaners who had high exposures for long periods of time.

The pattern of death among the reactor cleaners has been remarkably similar across the world. Cleaners die in their mid 50s, after 11 to 30 years (average 23 years) of exposure to vinyl chloride. The average time from the first exposure to time of diagnosis is 23 years. Though no clinical signs or symptoms or laboratory tests have been found to be specific for the early diagnosis of this cancer, fatigue, abdominal pain, weight loss, loss of appetite, nausea, vomiting, indigestion, chest pain and diarrhea are common complaints.

A mortality study of 4300 current and former workers in 17 PVC fabrication plants over 10 years showed no deaths due to angiosarcoma.[6]

Recent evidence indicates that other cancers may be associated with vinyl chloride. An association between vinyl chloride exposure and cancers of the brain, lungs and blood-forming and lymphatic systems has been suggested.[7,8] But, the evidence to date is not strong enough to conclude that vinyl chloride causes these cancers.[3] The International Agency for Research on Cancer (IARC) has reviewed reports of increased incidences of cancers of the digestive system, urinary tract, skin and breast (in women). The Agency concluded that insufficient evidence exists to show that vinyl chloride causes these cancers.[3]

---

* Note: Additional information can be obtained from the ICI Angiosarcoma Registry, Dr. Brian Bennet, Occupational Health Department, ICI Chemicals and Polymers Group, Hillhouse Site, P.O. Box 4, Thornton Cleveleys, Blackpool FY5 4Q0, England.

Vinyl Chloride Disease (Acroosteolysis)

The disease primarily affects the skin and bones of the hands and fingers and, to a lesser extent, the feet and toes. Symptoms include shortening and thickening of the fingers, hardening or swelling of the skin on the hands and fingers, and numbness and coldness of the hands and feet, particularly when exposed to cold (Raynaud's phenomenon). In severe cases, there is deterioration of the bones in the fingers. Degeneration of the bones in the toes, kneecap and hip joint has also been reported. Decreased blood supply due to thickening of the walls of the blood vessels in the hands may play a role in the development of this disease. A number of abnormalities in the immune system have been observed. It has been suggested that these immunological changes may also be associated with the development of the disease.[9]

Liver Disease

Symptoms of liver disease in reactor cleaners include hardening and thickening of the walls of the blood vessels in the liver leading to abnormal formation of scar tissue in the liver, an enlarged liver, elevated pressure in liver blood vessels, and injury to the stomach and esophagus.[10,11] Internal bleeding and vomiting of blood, reduced number of circulating white cells, an enlarged spleen, abdominal pain and wasting away are also present. Changes in liver function tests are seen only in the late stages of the disease.

Lung Disease

A number of studies have demonstrated small but detectable changes in lung function (for example, altered lung function tests and difficulty in breathing) and abnormalities on chest x-rays in PVC polymerization and fabrication workers.[12,13] A lung disorder in which dust particles accumulate in the lungs (pneumoconiosis) has also been seen in these workers. In many of these plants, workers were exposed not only to vinyl chloride but also to PVC dust. In these plants, exposure levels to PVC dust greatly exceeded concentrations permissible under currently acceptable practices of industrial hygiene. Inhalation of excessive levels of PVC dust, rather than vinyl chloride, over a prolonged period of time was probably associated with these changes in lung function.

Reproductive Effects

Among the symptoms experienced by workers in the old polymerization plants, reproductive effects, including impotence and loss of sex drive, were commonly reported.[14]

A single study of vinyl chloride-exposed males showed an increase in spontaneous abortion rates in their wives.[15] A number of criticisms have been made of this study, and it is impossible to draw any firm conclusions.[13,16]

Several studies of communities living close to PVC plants found increased rates of birth defects, particularly of the central nervous system.[16] It is not possible to draw any conclusions from these studies since there were exposures to other chemicals in the community, and life-style factors such as smoking,

alcohol intake and diet were not considered. In a follow-up study on one of these communities, none of the parents of the affected children had either worked at the PVC plant or lived within two miles of the plant. This would indicate that vinyl chloride was probably not the cause in those cases.[17]

Mutagenic Effects

There have been a number of reports of increased frequencies of chromosomal changes in the blood cells of workers exposed to vinyl chloride.[16] Most of these studies were carried out prior to 1975 when exposures to vinyl chloride were greater than 20 ppm.[16] Since then, two reports have demonstrated the disappearance of chromosomal changes in groups of workers followed periodically since 1975.[18,19] In addition, in a recent study of 209 workers whose exposure was estimated to be 12 ppm or lower,[20] no chromosomal abnormalities were observed. No difference was found in the number of chromosomal abnormalities when exposure levels were less than 5 ppm.[21]

Toxicity Data in Animal and Laboratory Tests

Effects of Short-Term Exposures

Vinyl chloride has a low toxicity following short-term exposures. The two-hour LC_{50} (the concentration in air which kills half of the animals following an exposure of two hours) for rats exposed by inhalation was 150,000 ppm; for mice, 113,000 ppm; for guinea pigs, 230,000 ppm; and for rabbits, 130,000 ppm.[8] Vinyl chloride has an anesthetic effect on experimental animals, the most sensitive species being mice, followed by rats, guinea pigs and rabbits.

Effects of Long-Term Exposures

Long-term exposure of guinea pigs to 100,000 ppm vinyl chloride by inhalation results in severe liver, kidney, spleen and lung damage.

Carcinogenic Effects

Vinyl chloride causes cancer in mice, rats and hamsters fed or breathing concentrations of 50 ppm or more.[8] Cancers were reported at several sites including the liver (angiosarcoma), kidney, brain, lung, breast and skin. Excess cancers in rats exposed to concentrations as low as 10 ppm have been reported.[8]

Mutagenic Effects

Vinyl chloride and several of its breakdown products have been found to cause genetic changes in tests with bacterial and animal cells.[3]

Reproductive Effects

There is no evidence that vinyl chloride causes birth defects (teratogenic effects) in animals. Exposure of rats (2500 ppm), rabbits (500 ppm) and mice (500 ppm) for seven hours per day from day six to day fifteen of pregnancy (day six to day eighteen for rabbits) did not result in birth defects in the offspring.[22]

IV. FIRE AND EXPLOSION HAZARDS

Vinyl chloride is extremely flammable and poses a serious fire and explosion hazard. Take precautions to prevent leaks in closed systems and to avoid contacts with sources of ignition. Carry out a carefully controlled maintenance program to reduce the possibility of leaks and spills to a minimum. Invisible leaks can be detected by using a soap solution or by instruments. Sensitive detection and warning devices are available which will detect vinyl chloride at levels well below 1 ppm.

Vapours are heavier than air and may travel a considerable distance to a source of ignition and flash back. Containers may explode in a fire.

The major products of combustion are hydrogen chloride gas, carbon monoxide, carbon dioxide and possibly traces of phosgene. The main sources of danger to personnel result from carbon monoxide and from the extensive formation of hydrogen chloride gas, as well as from any unburned vinyl chloride vapour. Since a major combustion product is hydrogen chloride, any time its pungent odour is detected the area should be evacuated. Only persons properly protected should enter the area.

The fire or explosion hazard of a substance is normally described by the flash point and flammable or explosive limits.

The flash point of vinyl chloride is -78°C (-108°F). When this material is at or above this temperature, enough vapour is produced to form a flammable or explosive mixture of vapour and air. An ignition source can cause this mixture to burn or explode.

The flammable or explosive range of the material in air is 3.6-33 percent (36,000-330,000 ppm). The lowest concentration of the material in air which can explode or burn is called the Lower Explosive Limit (LEL) or the Lower Flammable Limit (LFL). The LFL for vinyl chloride is about 3.6 percent (36,000 ppm). Similarly, the highest concentration of the material in air which can explode or burn is called the Upper Explosive Limit (UEL) or the Upper Flammable Limit (UFL). The UFL for vinyl chloride is 33 percent (330,000 ppm). Between the LFL and the UFL, hazards include the possibility of explosion or the possibility of flashback: a fire travelling along the line of vapour or gas from a spark or flame to a container or spill. When the concentration is below the LEL, the air/chemical mixture is too "lean" to burn, and when the concentration is above the UEL, the mixture is too "rich." Adequate ventilation can prevent the accumulation of explosive concentrations of the airborne material in work or storage areas.

The auto-ignition temperature for vinyl chloride is 472°C (882°F).

The auto-ignition temperature is the lowest temperature at which a material begins to burn in air in the absence of a spark or flame. Auto-ignition is a result of the chemical decomposition of the material. Auto-ignition temperatures can vary by 100°C or more depending on the test method used, so listed values should be considered approximate. Materials must be stored and handled at temperatures well below their auto-ignition temperature. A low auto-ignition temperature can indicate that a material is dangerously unstable or susceptible to spontaneous combustion.

V. CHEMICAL REACTIVITY

Commercial vinyl chloride is stable. It contains a polymerization inhibitor (phenol). Without the phenol, an unstable, potentially hazardous peroxide can form by oxidation with atmospheric oxygen when stored for prolonged periods in presence of a variety of contaminants. Exposure to oxygen, air, sunlight, oxidizing agents, metals such as copper and aluminum, and certain catalytic impurities can initiate polymerization. Heat generated by this reaction may also cause decomposition which liberates toxic amounts of hydrogen chloride gas.

VI. EXPOSURE LIMITS

The following exposure limit(s) have been established by the American Conference of Governmental Industrial Hygienists (ACGIH) for vinyl chloride:

A Time-Weighted Average limit (TWA) of 5 parts per million (ppm) or 10 milligrams per cubic metre (mg/m^3) - Appendix A1a - Recognized Carcinogens.

The Appendix A1a designation that appears after the suggested TLV is defined as follows:

> "Human Carcinogens. Substance or substances associated with industrial processes, recognized to have carcinogenic or co-carcinogenic potential with an assigned TLV."

Contact the appropriate authority in your jurisdiction for details of the specific regulations which apply. Most provincial jurisdictions have exposure limits below that of the ACGIH.

VII. EXPOSURE CONTROLS

Enclose all processes. Where openings are required, use local exhaust ventilation.

Protective Clothing

Wear protective clothing (gloves, aprons, coveralls, boots) as needed to prevent exposure of skin to liquid or concentrated vapours.

Clothing made with chlorinated polyethylene and Viton resist penetration and degradation by vinyl chloride. Butyl rubber, nitrile rubber and polyvinyl chloride appear to be unsuitable for protection against penetration by vinyl chloride.[23]

Promptly remove and discard or launder separately any clothing which becomes contaminated with vinyl chloride. Then thoroughly dry it before reusing.

Wear splash-proof chemical safety goggles or a face shield (eight-inch minimum) whenever there is a risk of splashing liquid into the eyes. Locate eyewash fountains and safety showers in areas where vinyl chloride splashes are likely to occur.

Respiratory Protection

Factors to be considered when implementing a respiratory protection program include:

- Selection of appropriate respirators
- Respirator fit testing
- Respirator maintenance
- Inspection
- Cleaning
- Program evaluation
- Worker training

These factors are described in more detail in CSA Standard Z94.4-M1982, "Selection, Care, and Use of Respirators," available from the Canadian Standards Association, Rexdale, Ontario, M9W 1R3.

The degree of respiratory protection required depends on the concentration of the vapour and the duration of the exposure. Because of the poor warning properties of vinyl chloride, the use of air-purifying respirators is not advisable. NIOSH[24] recommends the following respiratory protection for vinyl chloride vapour concentrations:

At any Detectable Concentration: Any self-contained breathing apparatus with full facepiece and operated in a pressure-demand or other pressure mode; any supplied-air respirator with a full facepiece and operated in pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

Escape: Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted canister providing protection against the compound of concern; any appropriate escape-type self-contained breathing apparatus.

VIII. STORAGE AND HANDLING

Store vinyl chloride in a cool, dry, well-ventilated, non-combustible place, preferably in an outside or detached storage area. Keep away from strong oxidizing agents and sources of heat or ignition.

Store cylinders at or above ground level, upright on a level, fireproof floor. Keep cylinders secured in position and protected from damage. Keep cylinder covers on. Keep cylinders out of sun. Label empty cylinders. Store full cylinders separately from empty ones. Do not store reserve stores of vinyl chloride with cylinders containing oxygen, chlorine or other highly oxidizing or flammable materials.

Limit quantity of material in storage and restrict access to storage area. Post warning signs when appropriate. Keep storage area separate from populated work areas and inspect periodically for deficiencies such as damage or leaks.

Comply with all applicable regulations for the storage and handling of compressed gases and flammable materials.

Move cylinders by hand-truck or cart designed for that purpose. Do not lift cylinders by their caps. Do not handle them with oily hands. Secure cylinders in place in an upright position at all times. Do not drop cylinders or permit them to bang against each other. Leave valve caps on until cylinders are secured and ready for use. Close all valves when not in actual use.

Ground all cylinders and lines containing vinyl chloride. Do not use near welding operations, sparking motors, hot surfaces or other non-explosion proof equipment.

IX. FIRST AID

The following general procedures are suggested for first aid involving poisoning by vinyl chloride.

Inhalation

Remove the source of contamination if this can be done safely or move the victim to fresh air. If breathing has stopped, have properly trained personnel begin artificial respiration or cardiopulmonary resuscitation (CPR) immediately. Obtain medical attention immediately.

Skin

As quickly as possible, flush the contaminated area with lukewarm, gently running water for at least 20 minutes. Remove contaminated clothing promptly, and discard or launder separately. Dry thoroughly before reuse. If frostbite has occurred, obtain medical attention.

Eyes

As quickly as possible, flush the contaminated eye(s) with lukewarm, gently flowing water for 20 minutes, holding the eyelid(s) open. Obtain medical attention immediately.

General

Consult a physician and/or the nearest Poison Control Centre for all exposures, except minor instances of inhalation and skin contact.

X. FIREFIGHTING

Stopping the flow of gas rather than extinguishing the fire is usually the best procedure to follow when escaping gas is burning. It may be dangerous to extinguish the flame and allow the gas to continue to flow. This is because an explosive mixture may be formed with air which, if ignited, could cause far greater damage than if the original fire had been allowed to burn. Extinguishing the fire with carbon dioxide or dry chemical may be necessary to permit immediate access to valves to shut off the supply. In many cases, it is preferable to allow the flame to continue, keeping the surroundings cool with water spray to

prevent ignition of other combustible materials. For small fires involving vinyl chloride, recommended types of extinguishers are carbon dioxide, dry chemical and halons. Streams of water cannot extinguish a liquid vinyl chloride fire because the monomer does not mix with water and will float on top. Water spray may also be used to cool containers involved in a fire to prevent rupture or explosion and to protect the workers shutting off the supply of gas. Only persons properly protected should enter the area.

XI. CLEAN-UP AND DISPOSAL

Provide adequate ventilation, protective equipment and appropriate respirators. Remove all sources of heat, sparks or flame before attempting to clean a spill. Stop flow if it can be done safely. Contain spilled material. Avoid skin contact. For small spills, evacuate area and let evaporate. For large spills, contact fire and emergency services and supplier for advice.

Consult the federal, provincial and local governments for advice on disposal. Do not place waste materials, equipment or other sources of vinyl chloride in closed containers in areas of excessive temperature or sunlight where an increase in internal pressure may rupture the container and cause a fire or explosion. Never discharge waste vinyl chloride directly into sewers or surface waters. Vinyl chloride can be burned in a high-temperature incinerator with a scrubber attached to remove any hydrochloric acid formed.

XII. REFERENCES

1. Halton, D.M. How workplace chemicals enter the body. Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1985.

2. Danziger, H. Accidental poisoning by vinyl chloride: report of two cases. Canadian Medical Association Journal. Vol. 82 (Apr. 16, 1960) p. 828-830.

3. IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans. Supplement 4, Chemicals, industrial processes and industries associated with cancer in humans. Lyon, France: International Agency for Research on Cancer, 1982. p. 260-262.

4. Creech, J.L. et al. Angiosarcoma of the liver in the manufacture of polyvinyl chloride. Journal of Occupational Medicine. Vol. 16, no. 3 (1974) p. 150-151.

5. Delorme, F. et al. Ten cases of angiosarcoma of the liver in Shawinigan, Quebec. Journal of Occupational Medicine. Vol. 20, no. 5 (1978) p. 338-340.

6. Chiazze, L. et al. Mortality among employees of PVC fabricators. Journal of Occupational Medicine. Vol. 19, no. 9 (1977) p. 623-628.

7. Waxweiler, R.J. et al. Neoplastic risk among workers exposed to vinyl chloride. Annals of the New York Academy of Sciences. Vol. 271 (1976) p. 40-48.

8. IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans. Vol. 19, Some monomers, plastics and synthetic elastomers, and acrolein. Lyon, France: International Agency for Research on Cancer, 1979. p. 377-439.

9. Ward, A.M. et al. Immunological mechanisms in the pathogenesis of vinyl chloride disease. British Medical Journal. Vol. 1 (Apr. 17, 1976) p. 936-938.

10. Lange, C.-E. et al. Die sogenannte Vinylchlorid-Krankheit : eine berufsbedingte Systemklerose? International Archives of Occupational Health. Vol. 32 (1974) p. 1-32.

11. Veltman, G. et al. Clinical manifestations and course of vinyl chloride disease. Annals of the New York Academy of Sciences. Vol. 246 (1975) p. 6-17.

12. Lilis, R. et al. Pulmonary changes among vinyl chloride polymerization workers. Chest. Vol. 69, no. 2, suppl. (1976) p. 299-303.

13. Rom, W.N. Environmental and occupational medicine. Boston, Mass.: Little, Brown, 1983. p. 579-588.

14. Walker, A.E. Clinical aspects of vinyl chloride disease: skin. In: Proceedings of the Royal Society of Medicine. Vol. 69 (June 12, 1976) p. 286-289.

15. Infante, P. et al. Genetic risks of vinyl chloride. The Lancet. Vol. 1 (Apr. 3, 1976) p. 1289-1290.

16. Barlow, S.M. et al. Reproductive hazards of industrial chemicals : an evaluation of animal and human data. London: Academic Press, 1982. p. 566-582.

17. Edmonds, L.D. et al. Congenital malformations and vinyl chloride. The Lancet. Vol. 2 (Nov. 29, 1975) p. 1098.

18. Hansteen, I.-L. et al. Effects of vinyl chloride in man: a cytogenetic follow-up study. Mutation Research. Vol. 51 (1978) p. 271-278.

19. Anderson, D. et al. Chromosomal analyses in vinyl chloride exposed workers: results from analysis 18 and 42 months after an initial sampling. Mutation Research. Vol. 79, no. 2 (1980) p. 151-162.

20. Picciano, D.J. et al. Vinyl chloride cytogenetics. Journal of Occupational Medicine. Vol. 19, no. 8 (1977) p. 527-530.

21. Rossner, P. et al. Cytogenetic analysis in workers occupationally exposed to vinyl chloride. Mutation Research. Vol. 73 (1980) p. 425-427.

22. John, J.A. et al. The effects of maternally inhaled vinyl chloride on embryonal and fetal development in mice, rats and rabbits. Toxicology and Applied Pharmacology. Vol. 39, no. 3 (1977) p. 497-513.

23. Schwoppe, A.D. et al. Guidelines for the selection of chemical protective clothing. 3rd edition. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1987.

24. NIOSH pocket guide to chemical hazards. Reprinted with corrections Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1987.

Note: Additional references on this subject are available from CCOHS upon request.

PLEASE NOTE

This summary was prepared at the Canadian Centre for Occupational Health and Safety (CCOHS) and is intended primarily as a source of information for persons who work with or may be occupationally exposed to this material. The information selected for inclusion is believed to be reliable and generally relevant to occupational health. Other information which bears on particular work situations may be available. The scientific data in many areas are limited and may allow a variety of interpretations. Additional information, corrections, comments and questions are welcome, and should be addressed to the Inquiries Service, CCOHS, 250 Main Street East, Hamilton, Ontario, L8N 1H6, (416) 572-2981; toll free 1-800-263-8276.

The information in this document was updated on June 24, 1987.